

SWEET POTATO FOR CLOSED ECOLOGICAL LIFE SUPPORT SYSTEMS
USING THE NUTRIENT FILM TECHNIQUE

P. A. Loretan, W. A. Hill, C. K. Bonsi, C. E. Morris, J. Y. Lu, C. R. A. Ogbuehi and D. G. Mortley. George Washington Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, AL

ABSTRACT

Sweet potatoes have been grown hydroponically using the nutrient film technique (NFT) in support of the CELSS program. Experiments in the greenhouse with the 'TI-155' sweet potato cultivar produced up to 1790 g/plant of fresh storage roots. Studies with both 'TI-155' and 'Georgia Jet' cultivars have resulted in an edible biomass index of approximately 260% with edible biomass linear growth rates of 12.1-66.0 g m⁻² d⁻¹ in 0.05-0.13 m² in 105 to 130 days. Proximate analysis of the storage roots indicated nutritive components similar to field grown sweet potatoes. Varietal selection studies showed the potential of other cultivars for this system. 'Georgia Jet' sweet potatoes grown in environmental chambers produced 545 g/plant in 90 days with a light intensity of 960 $\mu\text{mol m}^{-2} \text{s}^{-1}$. With 480 $\mu\text{mol m}^{-2} \text{s}^{-1}$ only 304 g/plant were produced. Experiments with various cultivars, photoperiods, light intensities and nutrient solution compositions are in progress. All studies indicate good potential for sweet potatoes in CELSS.

INTRODUCTION

Tuskegee University (TU) has been conducting research on sweet potatoes for CELSS since 1986. The various aspects of growing sweet potatoes for CELSS were reviewed by Hill et al. (1). Initial basic research needs were identified as: (a) the actual production of sweet potatoes in soilless media and (b) the optimization of parameters leading to optimal production. This presentation will briefly review some of the work conducted to address these needs.

GROWING SYSTEM

Preliminary investigations into hydroponic production of sweet potatoes involved aggregate studies (2). Such an aggregate system--sand in 10 L pots--was used to study the influence of

nutrient solutions with different N:K ratios (1:1.1 and 1:2.4) on the growth of 'Georgia Jet' and 'Jewel' sweet potatoes in 90 and 120 days. In each case, nutrient solutions with an N:K ratio of 1:2.4 tended to produce a higher storage root weight in this open hydroponic system (3). However, considering the mass and volume limitations of a space-based plant production system, the TU team fairly early designed a system making use of the nutrient film technique (NFT). Very little work had ever been done on such a hydroponic system for root crops.

The TU NFT system designed is described by Hill et al. (4) and includes three growth channels to which nutrient solution is supplied from a nutrient reservoir by a pump. The 15 cm sweet potato vine cuttings are spaced at 25 cm both within the channel and between channels. A black-white vinyl film encloses the channel preventing light from entering the root zone. As the foliage grows, it is supported by and trained onto a string from above the channel. Good storage root enlargement has resulted in this system.

REVIEW OF SELECTED EXPERIMENTS

Photoperiod Experiment. Since little is known about the effect of photoperiod on sweet potatoes, experiments were set up to study the effects of two photoperiods and temperature regimes on sweet potato production using reach-in growth chambers. Vine cuttings of three cultivars--'Georgia Jet', 'TI-155' and 'Georgia 120'--were placed in 4 L pots with a 1:1.1 mixture of sterilized sand and soil. The plants were subjected to a 24 h photoperiod or to a 12:12 h light/dark photoperiod, a constant temperature of 28°C or light/dark temperature regime of 28/22°C. A light irradiance of $360 \text{ } \mu\text{mol m}^{-2} \text{ s}^{-1}$ at canopy level and 70% RH were

maintained throughout the growing period. Results (Table 1) of the study with 'Georgia Jet' sweet potato provide a sample of the cultivar-specific data presented previously by Mortley et al. (5) and showed that the 24 h photoperiod increased storage root number, yield and fibrous root dry weights of the sweet potato. Some evidence of the positive effect of thermoperiodicity is reflected in storage root number and fibrous root dry weight. This study is now being conducted with 'TI-155' and 'Georgia Jet' cultivars using NFT.

Light Intensity--The effect of light intensity on the growth of 'Georgia Jet' sweet potato has been studied using the TU NFT system. The experiment was conducted using two environmental growth chambers and has been reported by Bonsi et al. (6). Sweet potatoes were grown under two light intensities for 85 days with a 14 h photoperiod, 70% RH and a 28:22°C diurnal temperature. Of the two light intensities, 480 and 960 $\mu\text{mol m}^{-2}\text{s}^{-1}$, plants grown with the latter produced the highest fresh and dry storage root weight: 545.3 and 104.6 g/plant, respectively (Table 2). There was no difference in number of storage roots or fresh or dry foliage weight caused by light intensity. The experiment is being repeated with the 'TI-155' cultivar.

Cultivar Studies. A number of experiments have been carried out in which the growth of different sweet potato cultivars has been monitored in both sand and NFT. The focus was on storage root yield. Hill et al. (4) reported on yields (Table 3) for three different cultivars--'Georgia Jet', 'Jewel' and 'TI-155.' 'Georgia Jet' grown in sand in pots outproduced 'Jewel' in 120 days. It has also produced up to 1308 g/plant in NFT in 105 days compared to 1790 g/plant produced with 'TI-155' in 130 days. In

these studies, the edible biomass index ranged from 60.0 - 89.2 % while the edible biomass linear growth rate ranged from 9.4 to 66 $\text{g m}^{-2}\text{d}^{-1}$ with a plant spacing of 0.05 - 0.13 m^2 . Preliminary screening of other sweet potato cultivars (Table 4) using NFT and a 120-day growing period identified both orange- and white-flesh cultivars for nutritional variety that have potential for CELSS (7).

NUTRITIVE PROXIMATE ANALYSIS OF SWEET POTATOES

Proximate analysis of 'Georgia Jet' sweet potato storage roots (Table 5) grown in NFT as compared to that for field-grown storage roots has been reported by Hill et al. (4). The data indicate that hydroponically-grown storage roots provide comparable nutrition to field-grown plants (8). Apparent differences in values can be attributed to the fact that the roots from the NFT system were analyzed immediately after harvest while the field-grown sweet potatoes were cured and stored prior to analysis. Carbohydrates and vitamins A and C are the major nutritional components from the 'Georgia Jet' roots which have an orange flesh. Preliminary research with white-flesh varieties such as 'TU-52' indicates they have virtually no vitamin A but are comparable in other nutrients.

CONCLUSIONS

Sweet potato appears to have good potential for CELSS. Experiments with sweet potatoes on the effect of various photoperiods, light intensities and cultivars have helped to indicate the range of parameters required for their good growth and storage root yield in NFT.

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Table 1. Effects of two photoperiod and temperature regimes on growth responses^z of 'Georgia Jet' sweet potato cultivar.

Photoperiod (Light/Dark)	Temp. (12/12)	Storage Roots No.	Roots Wt.	Fibrous Roots Dry Wt.	Foliage Wt. Fresh	Wt. Dry
(h)	(C)		(g)	(g)	(g)	(g)
12/12	28/28	0.7 b ^y	19.5 b	0.2 c	276.2 a	34.9 b
	28/22	1.0 b	11.0 b	4.3 b	242.5 a	25.8 c
24/0	28/28	2.3 b	187.9 a	0.4 c	306.6 a	47.4 a
	28/22	5.3 a	202.8 a	7.5 a	276.8 a	31.7 bc

^zMean of six plants.

^yMean separation in columns by DMRT (5% level). Means followed by the same letter are not significantly different.

Table 2. Growth of 'Georgia Jet' sweet potato under different light intensities in environmental growth chambers using the nutrient film technique (NFT).

Irradiance PPF ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	No.	Storage Root		Foliage	
		Fresh Wt.	Dry Wt.	Fresh Wt.	Dry Wt.
		(g/plant)		(g/plant)	
480	3.9 a*	304.1 b	58.7 b	396.7 a	51.7 a
960	4.2 a	545.3 a	104.6 a	342.0 a	57.5 a

*Mean of 12 plants grown in 90 days. Means in same column with same letter are not significantly different using Student t test at 5% level.

Table 3. Yield data for sweet potatoes grown in sand and NFT systems maintained in greenhouse.

Growing System	Cultivar	Duration (days)	Storage Fr. Wt.	Root Dry Wt.	Linear Growth Rate		Edible Biomass Harvest Index (%)
			Per Plant (g plant ⁻¹)	Per Plant (g plant ⁻¹)	Edible Biomass Canopy Area (g m ⁻² d ⁻¹)	Root Area (g m ⁻² d ⁻¹)	
Sand, pot	Georgia Jet	120	869*	203	14.1	52.0	89.2
			748**	175	12.1	44.8	87.6
Sand, pot	Jewel	120	606*	162	11.3	41.5	82.4
			505**	135	9.4	34.6	79.6
NFT	Georgia Jet	105	1308*	235	16.9	48.4	61.9
			949**	190	13.7	39.1	60.0
NFT	TI 155	130	1790*	397	23.1	66.0	-
			1493**	331	19.3	55.0	-

*Highest plant yield

**Mean of four plants

Table 4. Growth responses^z of four sweet potato cultivars grown in the Tuskegee University NFT system.

Cultivar	No.	Storage Roots	Foliage	
		Fresh Wt. (g)	Fresh Wt. (g)	Dry Wt. (g)
T2093	6.0 a ^y	322.6 a	188.4 ab	29.9 bc
TU 52	3.0 b	384.0 a	366.4 a	58.8 a
TU 80	3.0 b	305.9 a	74.8 b	14.1 c
TU 50	0.5 c	116.7 b	347.1 a	50.7 ab

^zMean of four plants

^yMean separation in columns by DMRT (5% level). Means followed by the same letter are not significantly different.

Table 5. Proximate analysis and comparison^x of 'Georgia Jet' sweet potato storage roots grown in the Tuskegee University NFT system and field grown roots.

Component	NFT System Content* per 100g (g)	Field Grown (g)
Moisture	78.5	77.4
Protein	1.0	- ⁺
Starch	12.9	18.6
Sugar	- ⁺	4.0
Vitamin B ₁ **	0.136	- ⁺
Vitamin B ₂ **	0.064	- ⁺
Vitamin C**	28.0	10.5
Carotenoids (Vitamin A)**	7.5	7.5

^x NFT system measurements made on fresh roots immediately after harvest; field grown measurements made on raw roots following curing and two weeks of storage.

*Wet basis

**mg per 100g

⁺ Not measured in this study